International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 51 - 56
https://irjaeh.com

Experiment Study on Strength of Concrete using Nanosilica

Mr. Mohamed Meera Maidheen[1], Ms. S. Bharathi [2], Dr. A.M. Arunmohan[3], Mr. Palanikumar[4], Paulraj T[5]

[1,2,4]Assistant professor, Civil Engineering, Sethu Institute of Technology, Kariapatti, India.

[3]Associate professor, Civil Engineering, Sethu Institute of Technology, Kariapatti, India.

[5]M. E Student, Department of Structural Engineering, Sethu Institute of Technology, Kariapatti, India.

Emails: *meeramaidheen@sethu.ac.in[1], bharathysanthanam@sethu.ac.in[2], arunmohan@sethu.ac.in[3], palanikumar@sethu.ac.in[4], abishekthomas70@gmail.com[5]*

Abstract

In recent times, the retrofitting of existing columns has become indispensable, necessitating the use of Carbon Fiber Reinforced Polymers (CFRPs) to fortify reinforced concrete columns. This application has led to notable enhancements in both strength and stability. Research, encompassing both experimental and theoretical approaches, has delved into the performance of concrete confined with CFRPs, particularly focusing on circular columns under concentric loading conditions. The findings from these studies indicate that CFRP confinement is more effective in circular columns compared to square columns. This is attributed to the concentration of stresses at the corners of square columns, resulting in a lower active area for CFRP confinement. Consequently, modifying square columns to a circular shape has been observed to enhance the effectiveness of CFRP confinement.

Keywords: *Fiber Reinforced Polymer, Carbon Fiber Sheets, Compressive Strength*

1. Introduction

In recent years, retrofitting existing columns has become essential, with Carbon Fiber fiber-reinforced polymers (CFRPs) being widely applied to strengthen them. [1] Both experimental and theoretical studies have consistently demonstrated that the use of CFRPs significantly enhances the strength and stability of reinforced concrete columns. Studies examining the stress-strain characteristics of [2] CFRP-confined concrete, specifically in circular columns under concentric loads, reveal that CFRP confinement demonstrates greater efficacy in circular columns than in square ones. This discrepancy arises primarily due to stress concentrations at the corners of square columns, leading to a reduced active area for CFRP confinement and subsequently lowering its efficiency. [3] As a result, the conversion of square columns into circular ones is considered a feasible approach to improve the effectiveness of CFRP confinement. The methodology is shown in Figure 1.

1.1 Experimental Methods or Methodology

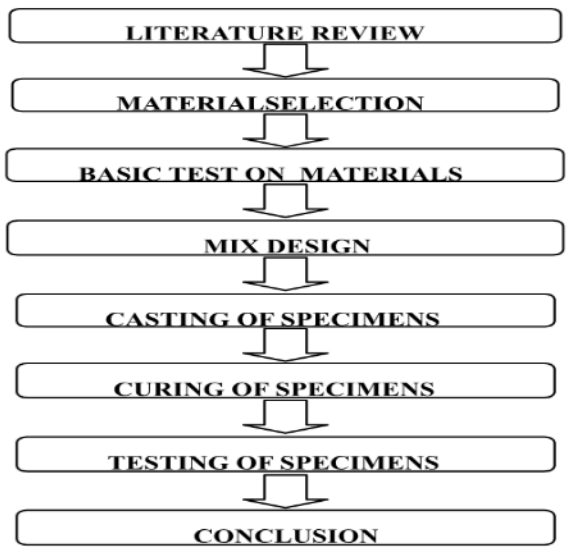


Figure 1 Methodology

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 51 - 56
https://irjaeh.com

2. Experimental Setup

All columns underwent axial compression testing using a 2000 KN capacity compression testing machine. [4] The columns were carefully positioned on supports to ensure alignment of their centerlines with the machine's axis. Instrumentation included linear voltage displacement transducers (LVDTs) to measure axial deformation, and a 2000 kN load cell to monitor load.[5] Both LVDTs and load cells were connected to a 16-channel Data Acquisition System for data storage. Load application was facilitated by an electronic jack, and the columns were tested until failure. Experimental observations (Figure 2) were made regarding failure mode, axial deformation, and ultimate load.

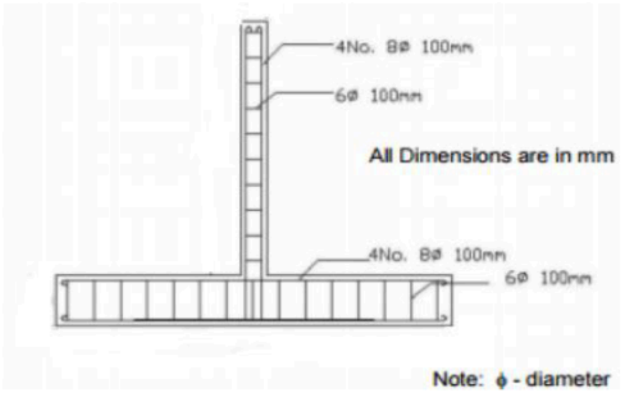


Figure 2 Experimental Setup

It is important to make the top and bottom surfaces of columns exactly flat to apply uniform load on both surfaces. Then the [6] saturated CFRP layers with epoxy were pasted onto the column surfaces. CFRP layers with epoxy are shown in Figure 3.

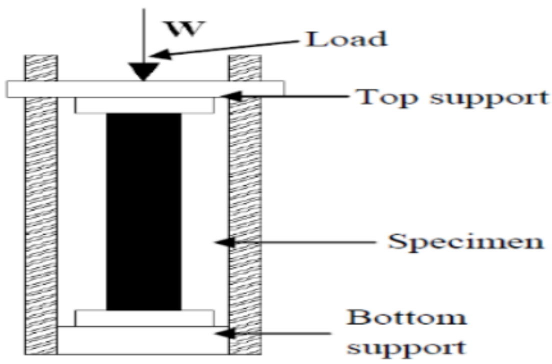
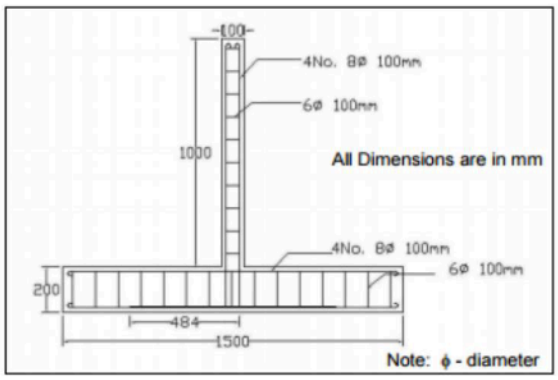


Figure 3 CFRP Layers with Epoxy

2.1 Loading arrangement

In the present experimental investigation, the wet lay-up technique was employed to establish a comprehensive CFRP confinement system. [7] This process involved preparing the surface and subsequently applying unidirectional CFRP. A 600 mm wide CFRP was positioned at the midpoint of the column, while 300 mm wide CFRP strips were affixed at both ends, creating a 100 mm overlap along the column's length. The overlap of CFRP strips in the transverse direction corresponded to the side of the cross-section. [8] Furthermore, to forestall premature failure, 200 mm wide CFRP strips were added at both ends of the specimens. Fully and partially fiber-wrapped test specimens and the Failure mode of conventional column specimens are shown in Figures 4 and 5.



a) Column without wrapping

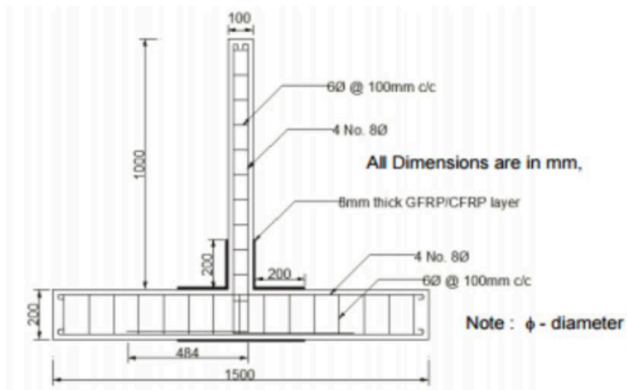


Figure 4 Fully and Partially Fiber-Wrapped Test Specimens

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 51 - 56
https://irjaeh.com

Figure 5 Failure Mode of Conventional Column Specimen

3. Results and Discussion

Table 1 Control column

Load (kN)	Displacement (mm)
0.0	2.4
0.5	5.8
1.0	10.25
1.5	23.50
2.0	45.25
2.5	74.15
3.0	106.25
3.5	143.35
4.0	182.15
4.5	218.15
5.0	254.12
5.5	290.15

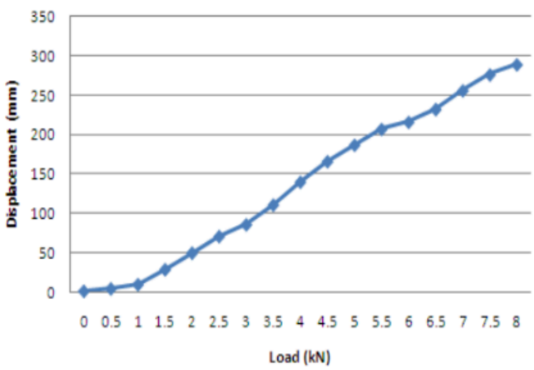


Table 2 Load-Displacement Control column

Load (kN)	Displacement (mm)
0.0	1.75
0.5	4.92
1.0	10.15
1.5	29.12
2.0	50.17
2.5	71.26
3.0	86.15
3.5	111.15
4.0	140.15
4.5	166.25
5.0	187.15
5.5	207.15
6.0	216.16
6.5	232.45
7.0	256.15
7.5	276.32
8.0	289.15

Table 3 Load-Displacement PWB-two Layer

Load (kN)	Displacement (mm)
0.0	2.35
0.5	4.46
1.0	7.47
1.5	14.25
2.0	26.12
2.5	40.15
3.0	55.16
3.5	80.12
4.0	104.15
4.5	126.56
5.0	162.42
5.5	204.15
6.0	244.25
6.5	286.15
7.0	305.15

7.5	332.15
8.0	349.15
8.5	370.15
9.0	383.12
9.5	401.15

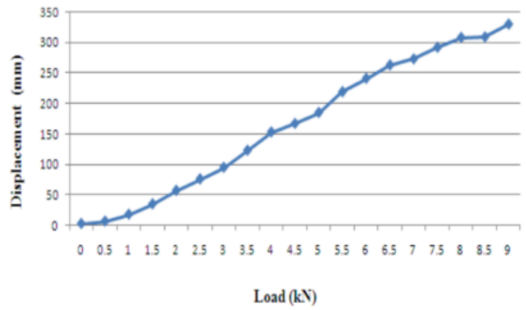


Table 4 Load-Displacement FWB-Double Layer

Load (kN)	Displacement (mm)
0.0	2.65
0.5	7.40
1.0	14.15
1.5	26.12
2.0	40.15
2.5	60.26
3.0	93.15
3.5	134.16
4.0	154.25
4.5	178.15
5.0	206.15
5.5	229.12
6.0	249.15

4. Experimental Results and Discussion

Each set of specimens underwent axial compression testing under concentric loading conditions. The results were tabulated in Table 1, Table 2, Table 3, and Table 4 and comparisons of load [9] versus axial deflection curves were presented for each group in Figure Several observations were noted:

- Specimens in Group N failed due to concrete spalling on the surface and buckling of the longitudinal reinforcement.
- Specimens in Groups RF and CF failed due to CFRP rupture at the mid-height, as depicted in Figures 4.6.5 and 4.6.6.
- The concrete at mid-height was completely crushed and restrained by CFRP.
- Aggregates of specimens in Groups RF and CF were entirely separated, contrasting with the concrete of Group N specimens.
- All specimens in Groups N, RF, and CF exhibited similar behavior in the initial stage of the curve, indicating that the concrete was not crushed.
- The load versus deflection diagrams showed that the slopes of the curves for specimens in Group CF were higher than those of specimens in Groups N and RF due to the larger cross-sectional area of Group CF.
- Loads of specimens in Groups CF and RF gradually increased [10] after the yield load, while loads decreased after the yield load in Group N specimens.
- Axial strain was calculated by dividing axial deformation by the actual length of the specimen, and the nominal average axial stress of specimens under concentric load was determined by dividing the axial load by the cross-sectional area of the specimens.
- The best confinement was observed in Specimen CF because the slope of the post-peak curve was higher than that of Specimen RF.
- In Groups CF and CS, no debonding was found between the core [11,12] concrete column and segmental sections, indicating that they both worked together until failure

Conclusion

CFRP has emerged as a prominent material within structural engineering applications, showcasing its potential advantages in construction both in academic research and practical field

implementations [13-15]. It has demonstrated cost-effectiveness in strengthening various structures such as concrete, masonry, steel, cast iron, and timber. Its utilization in the industry spans retrofitting existing structures for reinforcement or as an alternative to traditional steel reinforcement from project inception. When applied to reinforce concrete structures against flexure, CFRP typically delivers a significant boost in strength, often doubling or more the section's strength, while moderately increasing stiffness by approximately 10%. This is attributed to the high strength of CFRP material, with an ultimate tensile strength of around 3000 MPa, significantly surpassing that of mild steel, yet it exhibits slightly lower stiffness ranging from 150 to 250 GPa, comparable to steel [16]. Consequently, only small cross-sectional areas of CFRP are required for reinforcement, leveraging its high strength to amplify the structural strength without substantial stiffness improvements. CFRP can also be employed to enhance the shear strength of reinforced concrete by wrapping fabrics or fibers around the targeted building sections. Such wrapping, particularly around critical elements like bridges or columns, not only bolsters shear strength but also enhances the ductility of the structure, notably improving its resilience against collapse under seismic loading. This approach, known as 'seismic retrofit,' is particularly prevalent in earthquake-prone regions due to its superior cost-effectiveness compared to alternative methods [17].

References

[1]. Patel Abhiyan S., RathodHirenA. Neeraj Sharma.3,2013, An Overview on

[2]. Application of Nanotechnology in Construction Industry, International Journal of Innovative Research in Science, Engineering, and Technology, Vol. 2, Issue11,6094- 6098, ISSN: 2319-8753

[3]. Bharathi S, 2019 "Use of fly ash and plastic in bricks", International Journal of Emerging Technologies and innovative research, 41-44

[4]. Bharathi S, 2014, "An experimental investigation on utilization of red soil as replacement of fine aggregate in concrete", Psychology and Education, Volume 4 Issue 2, 8398-8403

[5]. Gu D.S., Wu G., Wu Z.S., Wu Y.F., "Confinement Effectiveness of FRP in Retrofitting Circular Concrete Columns under Simulated Seismic Load", Journal of composites for construction, Vol. 14 (5), 2010, pp. 531-540.

[6]. Harries K.A., Ricles J.R., Pessiki S., Sause R., "Seismic retrofit of lap splices in non-ductile square columns using carbon fiber-reinforced jackets", ACI Structural Journal, 103-S89, November/December 2006, pp. 874-884.

[7]. Hadi MNS., "Behaviour of FRP strengthened concrete columns under eccentric compression loading", Composites Structures, Vol 77, 2007, pp. 92-96.

[8]. Hadi MNS., "Behaviour of FRP wrapped normal strength concrete columns under eccentric loading", Composite Structures, Vol 72(4), 2006, pp.503–11.

[9]. Iacobucci R.D., Sheikh S.A., and Bayrak O., "Retrofit of Square Concrete Columns with Carbon Fiber-Reinforced Polymer for seismic resistance", ACI Structural Journal, 100-S81, November/December 2003, pp. 785-794.

[10]. Mohamed H. H., Dagher F., "Seismic Strengthening of Bond-Critical Regions in Rectangular Reinforced Concrete Columns Using Fiber-Reinforced Polymer Wraps", ACI Structural Journal, Vol 105(1), 2008, p. 68-77.

[11]. Promis G., Ferrier E., Hamelin P., "Effect of external FRP retrofitting on reinforced concrete short columns for seismic strengthening", Composite structures, Vol. 88(3), 2009, pp. 367-379.

[12]. Kaliyannan, Gobinath Velu, et al. "Investigation on sol-gel based coatings application in the energy sector–A review." Materials Today: Proceedings 45 (2021): 1138-1143.

[13]. Velu Kaliyannan, Gobinath, et al. "Utilization of 2D gahnite nanosheets as highly conductive, transparent and light trapping front contact for silicon solar cells." Applied Nanoscience 9 (2019): 1427-1437.
[14]. Sathishkumar, T. P., et al. "Investigation of chemically treated longitudinally oriented snake grass fiber-reinforced isophthallic polyester composites." Journal of Reinforced Plastics and Composites 32.22 (2013): 1698-1714.
[15]. Rathanasamy, Rajasekar, et al. "Carbon-based multi-layered films for electronic application: a review." Journal of Electronic Materials 50 (2021): 1845-1892.
[16]. Kandasamy, Suganeswaran, et al. "Corrosion behavioral studies on AA7075 surface hybrid composites tailored through friction stir processing." Anti-Corrosion Methods and Materials 67.4 (2020): 345-355.
[17]. Chinnasamy, Moganapriya, et al. "Effectiveness of cryogenic treatment on cutting tool inserts: A review." International Journal of Refractory Metals and Hard Materials (2022): 105946.